FEATURES

# An Empirical Assessment of the Value of Green in Residential Real Estate

*by Anjelita Cadena, PhD, and Thomas A. Thomson, PhD*

ABSTRACT

**This article uses about 66,000 home sales from October 2008 through September 2013 in the multiple listing service (MLS) of Bexar County (San Antonio), Texas, to evaluate the extent green components add value a house's selling price. This MLS classifies green items as "Green Designation," "Green Features," and "Energy Efficient Features." The study analysis finds that all of these classifications demonstrate a statistically significant increase in selling price in the Bexar County market: a Green Designation increases selling price by almost 1%, while a Green Feature increases selling price by about 2%, and an Energy Efficient Feature raises selling price by about 6%.**

Although there remains some controversy regarding the issue of human-induced climate change, there is always a market for money-saving devices, including those that increase energy and water use efficiency.[1] There are also nonpecuniary benefits of human comfort when a residence maintains its temperature with less cycling of heating and cooling devices, so it is reasonable that buyers would pay for comfort items as well as energy saving items.[2] Increased insulation and multi-glazed windows, which increase energy efficiency, will also make a home quieter. It is also likely that some environmentally conscious buyers will pay a premium, even in the absence of dollar savings or direct human comforts, to meet personal lifestyle choices that include minimizing their individual environmental impact.

While "green" is a term that is colloquially used to mean "environmentally friendly," it has more specific meaning when it is applied to building certifications and ratings. There are a number of green certifications that result from a specified and documented process to achieve the given certification; prominent examples include the Leadership in Energy and Environmental Design (LEED) certification[3] and the National Association of Home Builders' National Green Building Standard (NGBS) certification.[4] Energy efficiency is an important subset of green building.[5] Popular measures for overall energy efficiency include the Energy Star-qualified homes, and homes rated using the Home Energy Rating System (HERS).[6] In addition, buildings may have green or energy-efficient

1. According to the Energy Star website, "Compared with standard homes, Energy Star qualified homes use substantially less energy for heating, cooling, and water heating—delivering $200 to $400 in annual savings. Over the average 7 to 8 years you may live in your home, this adds up to thousands of dollars saved on utility bills. Additional savings on maintenance can also be substantial. Financing your home purchase using an Energy Star Mortgage or an energy efficient mortgage can also lead to savings." (From http://www.energystar.gov/index.cfm?c=new_homes.nh_features); accessed April 9, 2011.
2. Ibid. The Energy Star website also notes, "Properly installed energy-efficient improvements deliver better protection against cold, heat, drafts, moisture, pollution, and noise. An energy-efficient home helps ensure consistent temperatures between and across rooms, improved indoor air quality, and greater durability."
3. Information about LEED can be found at http://www.usgbc.org/leed.
4. Information about the NGBS certification is available at http://www.nahb.org/generic.aspx?genericContentID=194279.
5. "Green" generally refers to more than energy efficiency; for some further discussion see http://www.green-buildings.com/content/78308-leed-vs-energy-star.
6. Information about HERS is available at http://www.hersindex.com/.

features while the building as a whole does not have a green designation.

Some energy-efficient items can be added relatively easily on existing homes, and others are difficult or impossible to retrofit. For example, one San Antonio homebuilder uses a new approach to framing exterior walls to allow better insulation of the wall cavity; however, this feature cannot be retrofitted. If homeowners are willing to keep their thermostat a little higher in the summer and they have ceiling fans for aiding indoor comfort, some energy savings will result from the relatively simple addition of the ceiling fans. Highly efficient appliances, and heating and cooling systems can be chosen when these are being replaced, but when buying a home, it may require a wait until it would make economic sense to replace existing but serviceable appliances. Xeriscaping, that is landscaping to reduce or totally eliminate the need for watering by using drought resistant or tolerant plants, can be incorporated into an existing property in a cost-efficient manner but would be a questionable practice immediately after purchasing a home that is already landscaped. For existing homes, such investments may be prudent during the ordinary replacement cycle.

Ciochetti and McGowan summarize information from the US Energy Information Administration that shows buildings are the largest user of energy in the United States and represent 41% of total US energy consumption.[7] Ciochetti and McGowan also show that the square footage of residential real estate far exceeds that of commercial buildings and although residential buildings use less energy per square foot, in total they consume the most energy. An important question for residential real estate appraisers is, How much value does the presence of green or energy-efficient features add to residential real estate values?

One approach to addressing this question, when there are direct dollar savings, is to take the present value of these savings as an estimate of the increase value. In a recent article in *The Appraisal Journal*, Sandra Adomatis does a capable job presenting this approach in a residential context.[8] She follows this up with a more comprehensive article describing a larger set of green improvements.[9] Adomatis notes that one can search explicitly for comparable properties that employ similar green features for use as comparables. An alternative approach to value green features is to use a mass appraisal type model where one can identify the properties with green features and assess the value of the features through the statistical appraisal model.

Bloom, Nobe, and Nobe analyze a sample of 150 Energy Star homes and 150 other homes in Fort Collins, Colorado, and using a hedonic regression model find that Energy Star homes sell for a premium.[10] Unfortunately, they fail to report the size or selling prices of the homes that comprise their data making it difficult to generalize their result. In another sudy, Aroul and Hansz compare real estate values in two nearby communities north of Dallas, Texas, where one community has a mandatory green building program.[11] They find that the green requirement adds 2%–5% to the selling price of the homes.

The analysis presented in this article uses a hedonic mass appraisal model to empirically estimate the premium that green and energy-efficient features contribute to a house's selling price. Compared to the studies previously noted, this research includes a far richer data set (about 66,000 rather than 300–800 home sales) and a much deeper set of control factors (approximately 50 more than the noted studies).

## Data

In Fannie Mae Form 1004, the Uniform Residential Appraisal Report, the Improvements section allows for a description of "Additional Features (special energy efficient items, etc.)". Current lending guidelines may consider energy efficiency in their underwriting.[12] In keeping with current analysis of real estate values, the San Antonio Board of Realtors' Multiple Listing Service (SABOR MLS) includes a green data section. This section records information in three subcategories: "Green Designations," "Green Features," and "Energy Efficient Features" and this data is present in sales starting in October 2008. Throughout this article, these data fields

7. Brian A. Ciochetti and Mark D. McGowan, "Energy Efficiency Improvements: Do They Pay?" *Journal of Sustainable Real Estate* 2, no. 1 (2010): 305–333.
8. Sandra K. Adomatis, "Valuing High Performance Houses," *The Appraisal Journal* (Spring 2010): 195–201.
9. Sandra K. Adomatis, "Describing the Green House Made Easy," *The Appraisal Journal* (Winter 2012): 21–29.
10. Bryan Bloom, MaryEllen C. Nobe and Michael D. Nobe, "Valuing Green Home Designs: A Study of ENERGY STAR® Homes," *Journal of Sustainable Real Estate* 3, no. 1 (2011): 109–126.
11. Ramy R. Aroul and J. Andrew Hansz, "The Value of 'Green': Evidence from the First Mandatory Residential Green Building Program," *Journal of Real Estate Research* 34, no. 1 (2012): 27–49.
12. Information regarding energy–efficient mortgages can be found at: http://www.energystar.gov/index.cfm?c=mortgages.energy_efficient_mortgages.

present in the SABOR MLS will be used to empirically evaluate how these variables affect the selling prices of homes. Prior to October 2008, SABOR listing brokers sometimes used the MLS "Exterior Features" field to indicate energy-efficient features such as double pane windows, solar screens, and storm windows. Prior to October 2008, 39% of listings included at least one of these energy-efficient features. Since October 2008, when the new green data fields were added to the MLS, the number of listed features has increased (see Table 1 for details of the frequency of various green components). The MLS green components fall under the previously noted three categories: "Green Designation," for which there is a mix of certifications and ratings; "Green Features," such as drought tolerant plants; and "Energy Efficient Features," such as increased insulation or high-efficiency cooling systems. The SABOR MLS green data designations may not be entirely satisfactory; however, an advantage is that there are clear data fields to address green improvements, which makes it more likely that each listing includes any green improvements than if individual Realtors simply choose whether to include in the comments section green improvements in a totally undesignated manner. This gives the data set much more consistency.

The study analysis follows the categorization method by which the data was gathered in the MLS. Sales data was collected for 60 months of sales from October 2008 through September 2013. This data set contains 66,649 sales, with approximately 45% recording at least one Green Designation, Green Feature, or Energy Efficient Feature. This data is text based so the notations in these fields were analyzed and a set of comments were parsed that are summarized in Table 1. Table 1 shows that among the sales the most common Green Designation (GD)[13] is the Energy Star certification,[14] followed by the HERS rating, and then the local Build San Antonio Green (BSAG) certification.[15] The NGBS and the LEED certifications are much less common. Table 1 also presents identified Green Features (GF) that were listed in the SABOR MLS; in this subcategory, low flow commodes and drought tolerant plants are common features. In addition, Table 1 documents the types of Energy Efficient Features that were recorded in the MLS data. Energy-efficient windows (such as dual pane or low e), ceiling fans, and programmable thermostats were the most commonly recorded. Other popular items listed as Energy Efficient Features included energy-efficient HVAC systems, high levels of insulation, and radiant barriers.

**Table 1 Green Data Frequency in San Antonio Board of Realtors Residential Sales Data, October 2008–September 2013 (66,649 Home Sales)**

| Green Designation (GD) | | Green Features (GF) | | Energy Efficient Features (EEF) | |
|---|---|---|---|---|---|
| **Notation** | **N** | **Notation** | **N** | **Notation** | **N** |
| Energy Star | 4,528 | Low flow commode | 4,781 | Windows | 29,191 |
| HERS | 1,792 | Drought tolerant plants | 2,894 | Ceiling fan | 16,782 |
| Build SA Green | 570 | Low flow fixture | 1,748 | Program thermostat | 10,666 |
| NGBS | 76 | Enhanced air filtration | 889 | Insulation/barrier | 8,951 |
| LEED | 65 | Rain/freeze sensors | 1,157 | HVAC | 7,975 |
| | | Mechanical fresh air | 840 | Energy Star appliance | 6,757 |
| | | Irrigation control | 673 | Water heater | 2,484 |
| | | Rainwater catchment | 91 | Doors | 1,169 |
| | | | | Solar/wind | 171 |

13. Table 1 lists the features as they are provided in the SABOR MLS database. The authors are not endorsing this classification and note that Energy Star–qualified homes, for example, are not necessarily "green homes." These homes meet stated energy-efficiency targets and have an official designation and in the SABOR MLS, they are listed under the Green Designation category.

14. Energy Star is a program of the US Environmental Protection Agency (EPA). As noted at the Energy Star website, "To date, more than 8,500 home builders have partnered with EPA to construct more than 1 million ENERGY STAR qualified homes. The trend is clear. By choosing a home with the ENERGY STAR label, you can be confident that it will have an increasingly valued feature when the time comes to sell." (From http://www.energystar.gov/index.cfm?c=new_homes.nh_features; accessed April 9, 2011).

15. Information about Build San Antonio Green is available at http://buildsagreen.org/.

To illustrate the growing popularity of these items in the MLS listings, Figure 1 provides a time trend of these categories that demonstrates an upward trend. Recent data shows 54% of sales listed at least one Energy Efficient Feature, 15% listed at least one Green Feature, and almost 12% showed a Green Designation. Figure 2 plots a combined indicator of any of these features by age of home. This plot shows that almost 97% of new homes indicate some green benefit, with this falling to 83% for three-year-old homes and to 15% for homes age 50 and older.

In addition to the green data, the standard MLS data that is commonly used in hedonic house price appraisals was assembled. As is standard practice, the data was examined for nonsensical values and other obvious coding errors and these observations were removed from the data. Extreme outliers in terms of house price or size, that are not cogent to this analysis, were also eliminated. House prices in the data set range from $20,000 to $1,000,000 with a median selling price of $150,000. House size ranges from 400—9,772 square feet, with a median size of 1,998 square feet. House age ranges from new to 142 years, with a median age of 14 years.

## Methods

A standard hedonic pricing analysis that is often used in real estate valuation research is employed in this study. The model takes the form

$$\ln(Sale\ Price)_i = f(G_i, CV_i) \quad (1)$$

where:

$\ln(Sale\ Price)$ is the natural log of the house sale price
$G_i$ is a vector of green indicator variables as shown in Table 1
$CV_i$ is a vector of control variables that are frequently used in hedonic real estate studies

As is common in such models, the log of sale prices is used rather than sale prices as the dependent variable. By using the log of house prices, indicator variables can be interpreted as the percentage effect on sale prices; thus, the results apply to both low- and high-priced houses. If a green coefficient is 0.03, it means when the feature is present, the house will sell for 3% more. This is advantageous compared to a fixed dollar measure that says, for example, when the house has this feature it would sell for $3,000

**Figure 1 Percent of Homes Sold with Green Components, Time Trend**

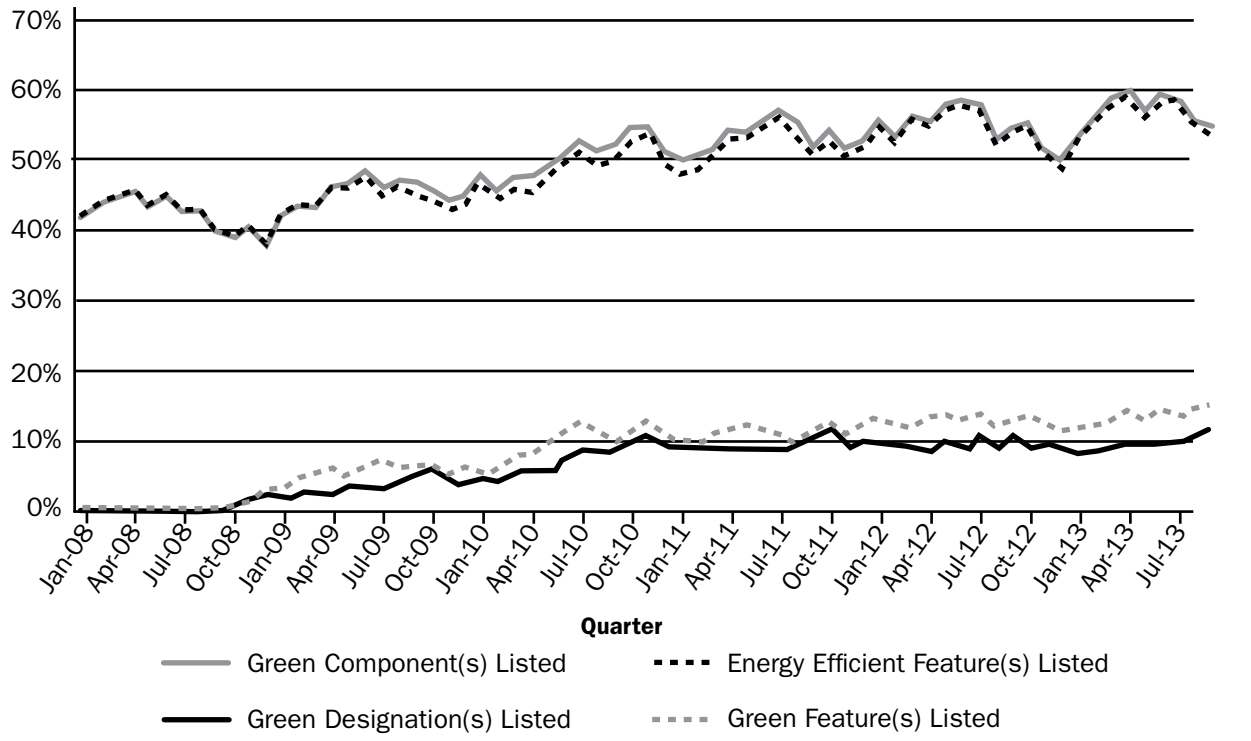
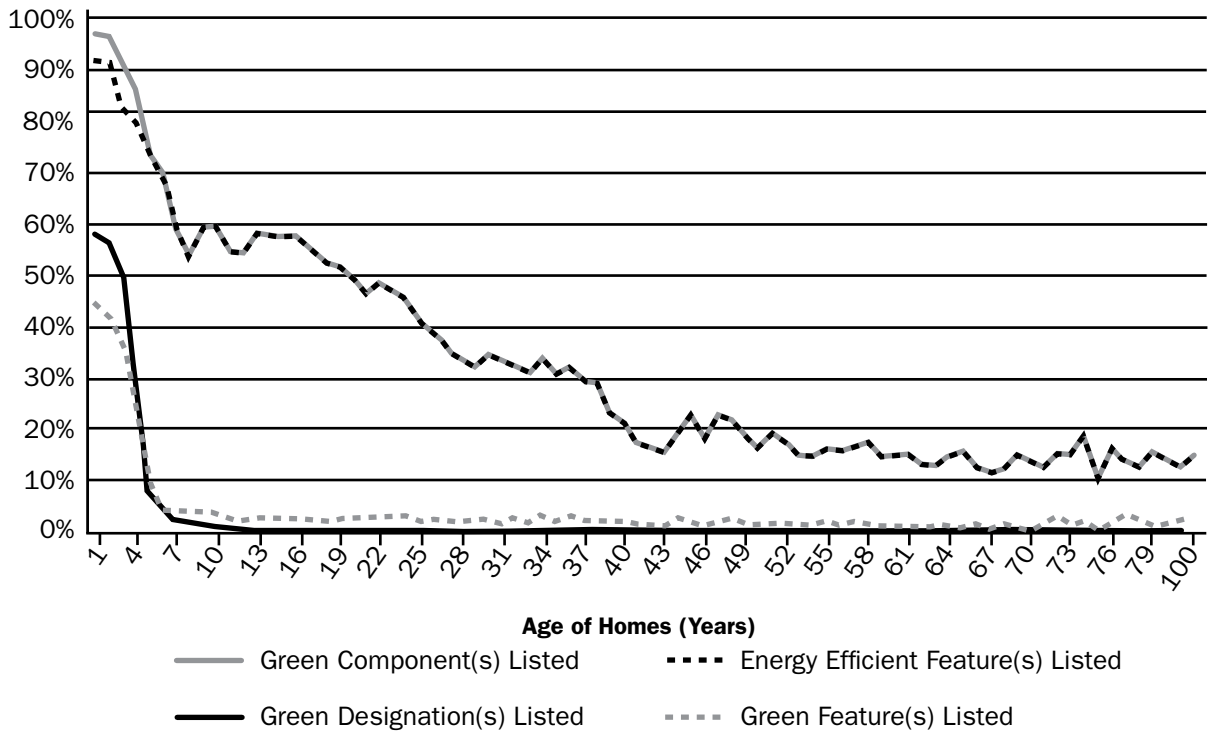


**Figure 2 Percent of Homes Sold with Green Components by Age of Home**




more, when the same feature on a smaller house might represent a smaller value gain, say $2,000, and on a larger house the feature might represent a larger value gain, say $4,000. The model is estimated using ordinary least squares.

Because green components may be part of a number of features common to high-quality houses, an extensive set of control variables was constructed to prevent the green indicators from simply indicating a highly valued house. Also, because newer houses tend to be more expensive than existing houses, and green components may be more prevalent in houses that are new or have been updated, cross tabs were analyzed for indicators of any such influences. A simple comparison of the average price of new houses to used houses finds that new houses sell for approximately 30% more than used houses. Similarly, houses with some type of green component sell for approximately 30% more than houses without green characteristics. This quick check, however, does not indicate this value gain can be attributed to the green component. It does suggest that care is needed in completing the analysis. The purpose of the control variables is to control for other features that add value to houses.

If green houses also tend to be large houses, part of the reason green houses sell for more is that they are larger. To accurately assess the contribution of the green characteristics, the model must have the size of the house as a control variable. As with standard hedonic models, the analysis used age, square feet, number of bathrooms, number of bedrooms, garage spaces, foundation, roof, and a two-story indicator to measure the basic variables that affect home values. In addition, controls were added for recent rehab work, need of repairs, vacant, and foreclosed properties. Exterior features were also used as control variables. Some exterior features, such a masonry or brick exteriors, could also be considered as green components as these exteriors tend to reduce energy costs. These are not part of the designated green characteristics in the SABOR database; thus, they are not treated as green variables. Controls were included for neighborhood amenities (golf course, controlled access, community centers, etc.). These variables often have a significant effect on house sale prices but are not the point of analysis for this study. As is common in hedonic real estate models, neighborhood indicator variables were included to allow for value differences among

neighborhoods. Monthly indicator variables, a standard control variable for hedonic models, were tested to assess any time trend in real estate values. During the study period, San Antonio house prices did not exhibit a statistically measurable time trend so these control variables were not used in the model results presented here.

Another concern in analyzing the data was the potential effects of correlations among the green measures. The Energy Star website states, "These homes are at least 15% more energy efficient than homes built to the 2004 International Residential Code (IRC), and include additional energy-saving features that typically make them 20%—30% more efficient than standard homes."[16] This reference goes on to note that effective insulation, high-performance windows, tight construction and ducts, energy-efficient heating and cooling systems, and energy efficient appliances and features are the route to achieve this rating. Most of these variables are present separately in the Energy Efficient Features part of the MLS database, which suggests there may be correlations among the green measures. Because of potential confounding effects of correlation among variables, the variables are analyzed separately, or in the three designated groups, or in ways that combine the measures into single indicator variables.

## Results

Table 2 present the model results, which are the regression coefficients for the green components. The overall $R^2$ variable is about 87% for all models, which means the model explains 87% of the variation in house prices. Table 2 also presents the *t*-statistics. When the absolute value of the *t*-statistics exceeds about 2.0, statisticians typically accept the results as statistically reliable. The results for the numerous control variables are not presented as they are not the focus of this study, but they are available from the authors on request.

Because it is common for a house that has one green aspect to have several green components, modeling the features jointly can lead to spurious results due to the correlation among the green variables. The individual results are presented by category, in line with the way they are recorded in the MLS, and then by using an indicator for the category. Finally, the results are presented using a single indicator variable of the presence of one or more green measure. Because the green variables are indicator variables, and because the log of home prices is used as the dependent variable, these coefficients can be interpreted as the percentage change in value when the indicator is present.

In Table 2, Model A presents the most common Green Designation indicators. The Energy Star designation is statistically significant and increases the value of a home by 1.1%. The HERS designation shows a negative value, but this may be because most homes that are HERS rated are also Energy Star qualified, leading to a spurious result. Because many homes have multiple designations, Model B presents the results with a single indicator for having at least one Green Designation; this variable is mildly statistically significant and raises the value of a home by 0.7%.

Model C in Table 2 presents results for Green Features. Of the eight features measured, drought tolerant plants, low flow commodes, and rain/freeze sensors[17] show a statistically significant but modest value increase of less than 2%. Rainwater catchment systems[18] show a much larger gain of 7.7%, but as shown in Table 1 this in an uncommon feature. Model D presents results using a single indicator for one or more Green Feature, which shows a statistically reliable 1.7% increase in value.

In Table 2, Model E presents the results for the various Energy Efficient Features. Several of the variables show statistical significance, with the strongest positive effects being presence of energy-efficient windows (3.8%), ceiling fans (2.1%), and water heater (1.5%). Interestingly, storm doors and Energy Star appliances show statistically negative impacts, while some other features, such as insulation and radiant barriers, show no statistically significant effect. While it is reasonable that a low-cost upgrade like a programmable thermostat would not provide any measurable value, it seems curious that storm doors would provide a negative value. As noted earlier, because many energy-efficiency

16. From http://www.energystar.gov/index.cfm?c=new_homes.nh_features (accessed April 9, 2011). In 2012, the EPA transitioned to more stringent requirements for Energy Star. Homes certified under the new requirements are at least 15% more energy efficient than those built to the 2009 International Energy Conservation Code; see http://www.energystar.gov/about/.

17. Rain sensors will prevent the landscape irrigation system from watering if there has been recent rainfall and thus reduce overall water usage.

18. Rainwater catchment systems are used to catch water during rainfalls to use for irrigation at a later period, which will reduce ground water usage.

variables are often present for the same house, such correlations can lead to spurious model fitting. A regression (not reported here) was run with only an indicator for storm doors and this variable showed no statistical significance, which suggests that the negative result is due to correlation with other variables. Model F presents the results for a single indicator for the presence of one or more Energy Efficient Features. This variable shows a statistically significant 5.8% effect on sale price.

Finally, Model G in Table 2 presents a single variable for the presence of one or more of the green measures. This overall result indicates that houses that exhibit one or more green element sell on average for 5.9% more than a similar house with no green element. This result is quite similar to the overall result for Energy Efficient Features, suggesting that Energy Efficient Features are the driving variable behind the green value increase.

## Conclusions

Houses with green characteristics provide energy and water savings, creature comforts, and potentially increase an owner's sense of environmental responsibility—all of which should add value to a home. The analysis presented here measures a statistically significant increase in sale price when homes have green characteristics. A green property in the SABOR MLS database (that is, one with Green Designation, Green Features, or Energy Efficient Features) sells at a 5.9% premium compared to otherwise identical properties. Because the article also reports results for the disaggregated data, the reader has flexibility in interpreting the results. Green Designations, which in the database primarily is an Energy Star certification, show a 0.7% selling price premium. Green Features, which in the database are primarily aspects that save water or improve air quality, provide a 1.7% premium. The most valuable single feature in the Green Features appears to be rainwater catchment, but this is also an uncommon feature; drought tolerant plants and low-flow commodes are more common value-increasing Green Features. Energy Efficient Features, such as windows, ceiling fans, and tankless hot water heaters add value. An overall indicator for presence of any of the Energy Efficient Features adds about 5.8% to the selling price of homes. These results are in line with those stated in the McGraw Hill Construction SmartMarket Report[19] surveys, which report that experienced green builders spend about 5.7% to incorporate green components in new homes and 7.5% in remodels and that most consumers indicate a preference to not pay more than a 4% premium for green components.

We can only be certain that the results apply to our data. However, we find no reason to assume buyers in San Antonio behave distinctly differently than others across the country. Although the results for other variables are not reported in this article, they are consistent with standard results, that is, newer houses, larger houses, house with more bathrooms, etc. have higher values. The MLS green data runs over five years giving some confidence that it is not a blip. It also runs across various neighborhoods, price points, and house ages. Over 66,000 transactions were analyzed, many of which demonstrate some form of green improvement. This leads one to conjecture that similar results would be found in other locations, though the magnitudes of value would reflect the local market.

19. *Green Multifamily and Single Family Homes: Growth in a Recovering Market*, retrieved from http://analyticsstore.construction.com/index.php/smartmarket-reports/2014GreenHomesSMR.html.

**Table 2 Ordinary Least Squares Regression Results, Green Components Only**

| Variable | Model A | | Model B | | Model C | | Model D | | Model E | | Model F | | Model G | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coef | *t*-stat | Coef | *t*-stat | Coef | *t*-stat | Coef | *t*-stat | Coef | *t*-stat | Coef | *t*-stat | Coef | *t*-stat |
| Intercept | 11.23 | 1556 | 11.23 | 1557 | 11.24 | 1556 | 11.24 | 1557 | 11.22 | 1556 | 11.22 | 1558 | 11.21 | 1556 |
| GD: Build San Antonio Green | –0.004 | –0.39 | | | | | | | | | | | | |
| GD: Energy Star | 0.011 | 2.75 | | | | | | | | | | | | |
| GD: HERS | –0.012 | –2.11 | | | | | | | | | | | | |
| GD: LEED | –0.023 | –0.98 | | | | | | | | | | | | |
| GD: NGBS | –0.024 | –1.03 | | | | | | | | | | | | |
| Any Green Designation | | | 0.007 | 1.93 | | | | | | | | | | |
| GF: Low flow commode | | | | | 0.008 | 2.22 | | | | | | | | |
| GF: Drought tolerant plants | | | | | 0.012 | 2.74 | | | | | | | | |
| GF: Low flow fixtures | | | | | 0.007 | 1.13 | | | | | | | | |
| GF: Rainwater catchment | | | | | 0.077 | 3.53 | | | | | | | | |
| GF: Rain/freeze sensors | | | | | 0.018 | 2.79 | | | | | | | | |
| GF: Irrigation controls | | | | | 0.003 | 0.37 | | | | | | | | |
| GF: Enhanced air filtration | | | | | 0.007 | 0.79 | | | | | | | | |
| GF: Mechanical fresh air | | | | | –0.039 | –4.51 | | | | | | | | |
| Any Green Feature | | | | | | | 0.017 | 5.90 | | | | | | |
| EEF: Solar/Wind | | | | | | | | | –0.003 | –0.19 | | | | |
| EEF: Energy Star appliances | | | | | | | | | –0.017 | –5.06 | | | | |
| EEF: Ceiling fans | | | | | | | | | 0.021 | 9.30 | | | | |
| EEF: Doors | | | | | | | | | –0.016 | –2.67 | | | | |
| EEF: HVAC | | | | | | | | | 0.006 | 1.83 | | | | |
| EEF: Insulation/barrier | | | | | | | | | –0.003 | –0.84 | | | | |
| EEF: Program thermostat | | | | | | | | | 0.004 | 1.30 | | | | |
| EEF: Water heater | | | | | | | | | 0.015 | 3.23 | | | | |
| EEF: Windows | | | | | | | | | 0.038 | 19.01 | | | | |
| EEF: Recirculate water heater | | | | | | | | | 0.006 | 0.38 | | | | |
| Any Energy Efficient Feature | | | | | | | | | | | 0.058 | 30.71 | | |
| Any Feature Noted Above | | | | | | | | | | | | | 0.059 | 30.89 |

Notes: The dependent variable is the log of sale price. Adjusted $R^2$ is about 87% for all models. Control variables not presented.

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## Web Connections

*Internet resources suggested by the Y. T. and Louise Lee Lum Library*

Appraisal Institute—Green Building Resources
*http://www.appraisalinstitute.org/education/education-resources/green-building-resources/*

Energy Star
—Buildings and Plants
*http://www.energystar.gov/buildings?s=footer*

—New Homes
*http://www.energystar.gov/index.cfm?c=new_homes.hm_index&s=footer*

National Association of Home Builders—Green Development
*http://www.nahb.org/reference_list.aspx?sectionID=1801*

National Association of Realtors
—Green Industry Articles
*http://www.greenresourcecouncil.org/green-resources/green-industry-articles*

—The Green MLS Tool Kit
*http://www.greenthemls.org/*

Residential Energy Services Network—Understanding the HERS Index
*http://www.hersindex.com/understanding*

US Energy Information Administration—Consumption and Efficiency
*http://www.eia.gov/consumption*

US Green Building Council—LEED
*http://www.usgbc.org/leed*